What is claimed is:

1. An objective lens for converging a first light flux of a first wavelength $\lambda 1$ emitted from a first light source so as to conduct reproducing and/or recording information for a first optical information recording medium including a first protective substrate having a thickness t1 ($0 \text{ mm} \leq t1 \leq 0.2$ mm) and for converging a second light flux of a second wavelength $\lambda 2$ ($\lambda 1 < \lambda 2$) emitted from a second light source so as to conduct reproducing and/or recording information for a second optical information recording medium including a second protective substrate having a thickness t2 ($t2 > t1$), comprising:

a first diffractive structure provided on at least one optical surface thereof and having plural concentric ring-shaped zones set such that n2, which is an order of a diffracted ray having the maximum light amount among diffracted rays generated when the second light flux comes into the first diffractive structure, is a lower order than n1, which is an order of a diffracted ray having the maximum light amount among diffracted rays generated when the first

light flux comes into the first diffractive structure, where n1 and n2 are an integer other than 0,

wherein the n1-th order diffracted ray is converged on an information recording surface of the first optical information recording medium through the first protective substrate in such a way that when a wavefront aberration is measured within a first numerical aperture NA1, the RMS value of the wavefront aberration becomes $0.07\lambda 1$ or less, and the n2-th order diffracted ray is converged on a information recording surface of the second optical information recording medium through the second protective substrate in such a way that when a wavefront aberration is measured within a second numerical aperture NA2 (NA2 < NA1), the RMS value of the wavefront aberration becomes $0.07\lambda 2$ or less.

2. The objective lens of claim 1, wherein the following formula is satisfied:

$$\lambda 2/\lambda 1 > 1.3$$

3. The objective lens of claim 1, wherein the following formula is satisfied:

$$n2 = \mathrm{INT}(\lambda 1 \cdot n1/\lambda 2)$$

$$|INT(\lambda 1 \cdot n1/\lambda 2) - (\lambda 1 \cdot n1/\lambda 2)| < 0.4$$

where n1 is an integer of 2 to 10, and $INT(\lambda 1 \cdot n1/\lambda 2)$ is an integer obtained by rounding the value of $(\lambda 1 \cdot n1/\lambda 2)$.

4. The objective lens of claim 3, wherein within the second numerical aperture NA2, the first diffractive structure has wavelength dependency of a spherical aberration such that when the wavelength of an incident light flux becomes longer, the spherical aberration changes to be under corrected, and the following formula is satisfied:

$$INT(\lambda 1 \cdot n1/\lambda 2) - (\lambda 1 \cdot n1/\lambda 2) > 0$$

5. The objective lens of claim 4, wherein the first diffractive structure is a blaze structure in which a stepped section is located at a closer side to the optical axis.

6. The objective lens of claim 4, wherein in the case that a first light flux of the first wavelength comes into the first diffractive structure, when an optical path difference added to a transmitted wavefront is represented by an optical path difference function Φ_b (mm) defined as a function of a height h (mm) from the optical axis by the formula of Φ_b =

$(\lambda 1/\lambda B) \cdot n1 \cdot (B_0 + B_2 \cdot h^2 + B_4 \cdot h^4 + B_6 \cdot h^6 + \ldots)$, (where B_2, B_4, B_6 … are coefficients of second, fourth, sixth, … order optical path difference functions, respectively, and λB is construction wavelength of the first diffractive structure), the following formula is satisfied:

$$-0.20 \leq f1/f_D < 0$$

where f_D is a focal length (mm) of the first diffractive structure defined by the formula of $f_D = \lambda B/(-2 \cdot n1 \cdot \lambda 1 \cdot B_2)$, and

f1 is a focal length (mm) of an entire system of the objective lens.

7. The objective lens of claim 6, wherein the first diffractive structure is a blaze structure and the optical surface on which the first diffractive structure is formed comprises a first region and a second region formed outside of the first region, and wherein a blaze structure is formed such that a stepped section formed on the first region is located at a farther side from the optical axis and a stepped section formed on the second region is located at a closer side to the optical axis.

8. The objective lens of claim 3, wherein within the second numerical aperture NA2, the first diffractive structure has wavelength dependency of a spherical aberration such that when the wavelength of an incident light flux becomes longer, the spherical aberration changes to be over corrected, and the following formula is satisfied:

$$\mathrm{INT}(\lambda 1 \cdot n1/\lambda 2) - (\lambda 1 \cdot n1/\lambda 2) < 0$$

9. The objective lens of claim 8, wherein the first diffractive structure is a blaze structure in which a stepped section is located at a farther side from the optical axis.

10. The objective lens of claim 8, wherein in the case that a first light flux of the first wavelength λ1 comes into the first diffractive structure, when an optical path difference added to a transmitted wavefront is represented by an optical path difference function Φ_b (mm) defined as a function of a height h (mm) from the optical axis by the formula of $\Phi_b = (\lambda 1/\lambda B) \cdot n1 \cdot (B_0 + B_2 \cdot h^2 + B_4 \cdot h^4 + B_6 \cdot h^6 + \ldots)$, (where B_2, B_4, B_6 … are coefficients of second, fourth, sixth, … order optical path difference functions, respectively, and λB is

construction wavelength of the first diffractive structure), the following formula is satisfied:

$$0.05 \leq f1/f_D < 0.25$$

where f_D is a focal length (mm) of the first diffractive structure defined by the formula of $f_D = \lambda B/(-2 \cdot n1 \cdot \lambda 1 \cdot B_2)$, and

f1 is a focal length (mm) of an entire system of the objective lens.

11. The objective lens of claim 10, wherein the first diffractive structure is a structure and the optical surface on which the first diffractive structure is formed comprises a first region and a second region formed outside of the first region, and wherein a blaze structure is formed such that a stepped section formed on the first region is located at a farther side from the optical axis a stepped section formed on the second region is located at a closer side to the optical axis.

12. The objective lens of claim 1, wherein a combination of n1 and n2 is (n1, n2) = (2, 1), (3, 2), (5, 3) or (8, 5), and the following formulas are satisfied:

$$390\ nm < \lambda 1 < 420\ nm$$

$$640\ nm < \lambda 2 < 670\ nm$$

13. The objective lens of claim 12, wherein the combination of n1 and n2 is (n1, n2) = (2, 1).

14. The objective lens of claim 12, wherein the combination of n1 and n2 is (n1, n2) = (3, 2).

15. The objective lens of claim 1, wherein the objective lens comprises a single lens having a positive power and the first diffractive structure is formed on a side of the optical surface where a light flux emitted from the first light source and the second light source comes into.

16. The objective lens of claim 15, wherein the following formulas are satisfied:

$$NA1 > 0.8$$

$$0.8 < d/f1 < 1.6$$

where d is a lens thickness (mm) on the optical axis, and f1 is a focal length (mm) of an entire system of the objective lens for the first wavelength λ1.

17. The objective lens of claim 1, wherein the objective lens comprises a single refractive lens having a positive power and an optical element at a side where a light flux emitted from the first light source and the second light source comes into, and the following formula is satisfied:

$$0 \leq |P_{L2}/P_{L1}| \leq 0.2$$

where P_{L1} is a paraxial power (mm^{-1}) of the single refractive lens for the first wavelength $\lambda 1$ and P_{L2} is a paraxial power (mm^{-1}) of the optical element for the first wavelength $\lambda 1$.

18. The objective lens of claim 16, wherein the single refractive lens is optimized such that a spherical aberration for the first wavelength $\lambda 1$ becomes minimum in accordance with the thickness of the first protective layer.

19. The objective lens of claim 18, wherein the following formulas are satisfied:

$$NA1 > 0.8$$

$$0.8 < dL1/fL1 < 1.6$$

where dL1 is a lens thickness (mm) of the single refractive lens on the optical axis, and fL1 is a focal length (mm) of the single refractive lens for the first wavelength $\lambda 1$.

20. The objective lens of claim 1, wherein the number of the ring-shaped zones of the first diffractive structure within the second numerical aperture NA2 is in a range of 10 to 60.

21. The objective lens of claim 1, wherein the following formula is satisfied:

$$0.03 < |(\Delta SA/\Delta\lambda)/\{(NA2)^4 \cdot f1\}| < 0.14$$

where $(\Delta SA/\Delta\lambda)$ represents a change ratio (λRMS/nm) of a spherical aberration on the first diffractive structure within the second numerical aperture NA2 in the case that the first wavelength $\lambda 1$ changes within a range of ± 10 nm, and f1 is a focal length (mm) of an entire system of the objective lens for the first wavelength $\lambda 1$.

22. The objective lens of claim 1, wherein the following formula is satisfied:

$$0.0008 < |(\Delta SA_M/\Delta\lambda)/\{(NA2)^2 \cdot f1\}| < 0.0021$$

where $(\Delta SA_M/\Delta\lambda)$ represents a change ratio (mm/nm) of a spherical aberration of a marginal ray of the second numerical aperture NA2 in the case that the first wavelength $\lambda 1$ changes within a range of ± 10 nm, and f1 is a focal length (mm) of an entire system of the objective lens for the first wavelength $\lambda 1$.

23. The objective lens of claim 1, wherein the second light flux which has passed through an outside region of the second numerical aperture NA2 and arrives a information recording plane of the second information recording medium has a spherical aberration of 0.07 $\lambda 2$RMS or more within the first numerical aperture NA1.

24. The objective lens of claim 1, wherein the following formula is satisfied:

$$m1 = m2 = 0$$

where m1 is a first magnification when reproducing and/or recording information is conducted for the first optical information recording medium and m2 is a second magnification when reproducing and/or recording information is conducted for the second optical information recording medium.

25. The objective lens of claim 1, wherein the following formula is satisfied:

$$m1 > m2$$

where m1 is a first magnification when reproducing and/or recording information is conducted for the first optical information recording medium and m2 is a second magnification when reproducing and/or recording information is conducted for the second optical information recording medium.

26. The objective lens of claim 1, wherein an optical surface of the objective lens comprises a central region located inside of the second numerical aperture NA2 and a peripheral region located outside of the second numerical aperture NA2 so as to surround the central region, and wherein the first diffractive structure is formed on the central region and a second diffractive structure optimized with the first wavelength $\lambda 1$ is formed on the peripheral region.

27. The objective lens of claim 1, wherein an optical surface of the objective lens comprises a central region located inside of the second numerical aperture NA2 and a

peripheral region located outside of the second numerical aperture NA2 so as to surround the central region, and wherein the first diffractive structure is formed only on the central region and the peripheral region is a continuous surface.

28. An optical pickup apparatus, comprising:

a first light source to emit a first light flux of a first wavelength $\lambda 1$;

a second light source to emit a second light flux of a second wavelength $\lambda 2$ ($\lambda 1 < \lambda 2$);

an objective lens for covering the first light flux so as to conduct reproducing and/or recording information for a first optical information recording medium including a first protective substrate having a thickness t1 ($0 \text{ mm} \leq t1 \leq 0.2$ mm) and for converging the second light flux so as to conduct reproducing and/or recording information for a second optical information recording medium including a second protective substrate having a thickness t2 ($t2 > t1$), the objective lens including:

a first diffractive structure provided on at least one optical surface thereof and having plural concentric ring-

shaped zones set such that n2, which is an order of a diffracted ray having the maximum light amount among diffracted rays generated when the second light flux comes into the first diffractive structure, is a lower order than n1, which is an order of a diffracted ray having the maximum light amount among diffracted rays generated when the first light flux comes into the first diffractive structure, where n1 and n2 are an integer other than 0,

wherein the n1-th order diffracted ray is converged on an information recording surface of the first optical information recording medium through the first protective substrate in such a way that when a wavefront aberration is measured within a first numerical aperture NA1, the RMS value of the wavefront aberration becomes $0.07\lambda1$ or less, and the n2-th order diffracted ray is converged on a information recording surface of the second optical information recording medium through the second protective substrate in such a way that when a wavefront aberration is measured within a second numerical aperture NA2 (NA2 < NA1), the RMS value of the wavefront aberration becomes $0.07\lambda2$ or less.

29. The optical pickup apparatus of claim 28, wherein the following formula is satisfied:

$$\lambda 2/\lambda 1 > 1.3$$

30. The optical pickup apparatus of claim 28, wherein the following formula is satisfied:

$$n2 = INT(\lambda 1 \cdot n1/\lambda 2)$$

$$|INT(\lambda 1 \cdot n1/\lambda 2) - (\lambda 1 \cdot n1/\lambda 2)| < 0.4$$

where n1 is an integer of 2 to 10, and $INT(\lambda 1 \cdot n1/\lambda 2)$ is an integer obtained by rounding the value of $(\lambda 1 \cdot n1/\lambda 2)$.

31. The optical pickup apparatus of claim 30, wherein within the second numerical aperture NA2, the first diffractive structure has wavelength dependency of a spherical aberration such that when the wavelength of an incident light flux becomes longer, the spherical aberration changes to be under corrected, and the following formula is satisfied:

$$INT(\lambda 1 \cdot n1/\lambda 2) - (\lambda 1 \cdot n1/\lambda 2) > 0$$

32. The optical pickup apparatus of claim 31, wherein the first diffractive structure is a blaze structure in which a

stepped section is located at a closer side to the optical axis.

33. The optical pickup apparatus of claim 31, wherein in the case that a first light flux of the first wavelength comes into the first diffractive structure, when an optical path difference added to a transmitted wavefront is represented by an optical path difference function Φ_b (mm) defined as a function of a height h (mm) from the optical axis by the formula of $\Phi_b = n1 \cdot (B_0 + B_2 \cdot h^2 + B_4 \cdot h^4 + B_6 \cdot h^6 + \ldots)$, (where B_2, B_4, B_6 … are coefficients of second, fourth, sixth, … order optical path difference functions, respectively, and λB is construction wavelength of the first diffractive structure), the following formula is satisfied:

$$-0.20 \leq f1/f_D < 0$$

where f_D is a focal length (mm) of the first diffractive structure defined by the formula of $f_D = \lambda B/(-2 \cdot n1 \cdot \lambda 1 \cdot B_2)$, and

f1 is a focal length (mm) of an entire system of the objective lens.

34. The optical pickup apparatus of claim 33, wherein the first diffractive structure is a blaze structure and the optical surface on which the first diffractive structure is formed comprises a first region and a second region formed outside of the first region, and wherein a blaze structure is formed such that a stepped section formed on the first region is located at a farther side from the optical axis and a stepped section formed on the second region is located at a closer side to the optical axis.

35. The optical pickup apparatus of claim 30, wherein within the second numerical aperture NA2, the first diffractive structure has wavelength dependency of a spherical aberration such that when the wavelength of an incident light flux becomes longer, the spherical aberration changes to be over corrected, and the following formula is satisfied:

$$\mathrm{INT}(\lambda 1 \cdot n1/\lambda 2) - (\lambda 1 \cdot n1/\lambda 2) < 0$$

36. The optical pickup apparatus of claim 35, wherein the first diffractive structure is a blaze structure in which a

stepped section is located at a farther side from the optical axis.

37. The optical pickup apparatus of claim 35, wherein in the case that a first light flux of the first wavelength $\lambda 1$ comes into the first diffractive structure, when an optical path difference added to a transmitted wavefront is represented by an optical path difference function Φ_b (mm) defined as a function of a height h (mm) from the optical axis by the formula of $\Phi_b = (\lambda 1/\lambda B) \cdot n1 \cdot (B_0 + B_2 \cdot h^2 + B_4 \cdot h^4 + B_6 \cdot h^6 + \ldots)$, (where B_2, B_4, B_6 … are coefficients of second, fourth, sixth, … order optical path difference functions, respectively, and λB is construction wavelength of the first diffractive structure), the following formula is satisfied:

$$0.05 \leq f1/f_D < 0.25$$

where f_D is a focal length (mm) of the first diffractive structure defined by the formula of $f_D = \lambda B/(-2 \cdot n1 \cdot \lambda 1 \cdot B_2)$, and

f1 is a focal length (mm) of an entire system of the objective lens.

38. The optical pickup apparatus of claim 37, wherein the first diffractive structure is a blaze structure and the optical surface on which the diffractive structure is formed comprises a first region and a second region formed outside of the first region, and wherein a blaze structure is formed such that a stepped section formed on the first region is located at a farther side from the optical axis a stepped section formed on the second region is located at a closer side to the optical axis.

39. The optical pickup apparatus of claim 28, wherein a combination of n1 and n2 is (n1, n2) = (2, 1), (3, 2), (5, 3) or (8, 5), and the following formulas are satisfied:

$$390\ \mathrm{nm} < \lambda 1 < 420\ \mathrm{nm}$$

$$640\ \mathrm{nm} < \lambda 2 < 670\ \mathrm{nm}$$

40. The optical pickup apparatus of claim 39, wherein the combination of n1 and n2 is (n1, n2) = (2, 1).

41. The optical pickup apparatus of claim 39, wherein the combination of n1 and n2 is (n1, n2) = (3, 2).

42. The optical pickup apparatus of claim 28, wherein the objective lens comprises a single lens having a positive power and the first diffractive structure is formed on a side of the optical surface where a light flux emitted from the first light source and the second light source comes into.

43. The optical pickup apparatus of claim 42, wherein the following formulas are satisfied:

$$NA1 > 0.8$$

$$0.8 < d/f1 < 1.6$$

where d is a lens thickness (mm) on the optical axis, and f1 is a focal length (mm) of an entire system of the objective lens for the first wavelength λ1.

44. The optical pickup apparatus of claim 28, wherein the objective lens comprises a single refractive lens having a positive power and an optical element at a side where a light flux emitted from the first light source and the second light source comes into, and the following formula is satisfied:

$$0 \leq |P_{L2}/P_{L1}| \leq 0.2$$

where P_{L1} is a paraxial power (mm^{-1}) of the single refractive lens for the first wavelength $\lambda 1$ and P_{L2} is a paraxial power (mm^{-1}) of the optical element for the first wavelength $\lambda 1$.

45. The optical pickup apparatus of claim 43, wherein the single refractive lens is optimized such that a spherical aberration for the first wavelength $\lambda 1$ becomes minimum in accordance with the thickness of the first protective layer.

46. The optical pickup apparatus of claim 45, wherein the following formulas are satisfied:

$$NA1 > 0.8$$

$$0.8 < dL1/fL1 < 1.6$$

where dL1 is a lens thickness (mm) of the single refractive lens on the optical axis, and fL1 is a focal length (mm) of the single refractive lens for the first wavelength $\lambda 1$.

47. The optical pickup apparatus of claim 28, wherein the number of the ring-shaped zones of the first diffractive structure within the second numerical aperture NA2 is in a range of 10 to 60.

48. The optical pickup apparatus of claim 28, wherein the following formula is satisfied:

$$0.03 < |(\Delta SA/\Delta\lambda)/\{(NA2)^4 \cdot f1\}| < 0.14$$

where $(\Delta SA/\Delta\lambda)$ represents a change ratio (λRMS/nm) of a spherical aberration on the first diffractive structure within the second numerical aperture NA2 in the case that the first wavelength $\lambda 1$ changes within a range of ± 10 nm, and f1 is a focal length (mm) of an entire system of the objective lens for the first wavelength $\lambda 1$.

49. The optical pickup apparatus of claim 28, wherein the following formula is satisfied:

$$0.0008 < |(\Delta SA_M/\Delta\lambda)/\{(NA2)^2 \cdot f1\}| < 0.0021$$

where $(\Delta SA_M/\Delta\lambda)$ represents a change ration (mm/nm) of a spherical aberration of a marginal ray of the second numerical aperture NA2 in the case that the first wavelength $\lambda 1$ changes within a range of ± 10 nm, and f1 is a focal length (mm) of an entire system of the objective lens for the first wavelength $\lambda 1$.

50. The optical pickup apparatus of claim 28, wherein the second light flux which has passed through an outside region

of the second numerical aperture NA2 and arrives a information recording plane of the second information recording medium has a spherical aberration of 0.07 $\lambda 2$RMS or more within the first numerical aperture NA1.

51. The optical pickup apparatus of claim 28, wherein the following formula is satisfied:

$$m1 = m2 = 0$$

where m1 is a first magnification when reproducing and/or recording information is conducted for the first optical information recording medium and m2 is a second magnification when reproducing and/or recording information is conducted for the second optical information recording medium.

52. The optical pickup apparatus of claim 28, wherein the following formula is satisfied:

$$m1 > m2$$

where m1 is a first magnification when reproducing and/or recording information is conducted for the first optical information recording medium and m2 is a second magnification when reproducing and/or recording information is conducted for the second optical information recording medium.

53. The optical pickup apparatus of claim 28, wherein an optical surface of the objective lens comprises a central region located inside of the second numerical aperture NA2 and a peripheral region located outside of the second numerical aperture NA2 so as to surround the central region, and wherein the first diffractive structure is formed on the central region and a second diffractive structure optimized with the first wavelength $\lambda 1$ is formed on the peripheral region.

54. The optical pickup apparatus of claim 28, wherein an optical surface of the objective lens comprises a central region located inside of the second numerical aperture NA2 and a peripheral region located outside of the second numerical aperture NA2 so as to surround the central region, and wherein the first diffractive structure is formed only on the central region and the peripheral region is a continuous surface.

55. An optical information recording reproducing apparatus, comprising:

the optical pickup apparatus described in claim 28; and

a supporting device to support a first optical information recording medium and a second information recording medium in such a way that the optical pickup apparatus can conduct recording and/or reproducing information.